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Original Article

DESIGN AND ANALYSIS OF A SOFT FINGER END EFFECTOR FOR INDUSTRIAL PURPOSE

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ABSTRACT

In this paper, there is a detailed explanation of our design, the soft finger end effector for the industrial purposes. As the designing of the end effectors plays a crucial role in the performance of a robotic arm. For the Soft fingers in the robotic arm the most important and crucial in this research was their properties such as (body shapes, softness, density).The detailed research regarding the soft finger will also include the approach for prediction of the force required and the weight that a finger can sustain are included in this research process. Apart from the firm wireless soft finger which process its movement through the sensors and actuators, instead of this wireless technology we made our design using wires in and around the soft finger. As the material used for the soft finger is silicon rubber / synthetic rubber when we apply force to pull the fingers close to a grasp an object as we don't need any mechanism to pull back the soft finger to its original position as it by nature rubber material as soon as the tension on it removed it will go back to its original position without any external forces acting on it. This paper introduces a new design and the recent technology development in the soft robotics field. The soft robotic finger must be a light weight and must possess the ability to grab and hold the objects irrespective of their shape and size.

KEYWORDS: Soft Finger, End Effectors, Silicon Rubber, Grasp & External Forces

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1. INTRODUCTION

Robotic Soft finger in previous age before the evolution of this soft finger it is called as robotic gripper, which is attached at the end of the industrial robotic arm. As the ages move on the and the technology is developing day by day these hard grippers which are used to grasp the objects which are hard enough that they won't burst out due to the hard grasping of the robotic grippers, but now it has been changed and in the place of the gripper soft finger has been introduced in the world to grasp any kind of object irrespective of its shape, size, structure. As the grippers which are connected to the end effector of the industrial robotic arm to develop a task in the work floor of that particular industry. The function of the gripper in ages ago was to open and close its jaw and while the technology increases these grippers are transformed into a new way and they become smarter that they not only open and close its jaw but it also moving the objects by grasping into its jaw from one place to another place. The soft finger that is going to design in this project was a little bit smarter using threads so that it will be called as wired soft finger, the wire which is passed in between the soft finger as like of nerves in the human hand

finger. These wires will act to pull the fingers together to grasp an object and in the release time the nature of the material will act on the soft finger to come back to its original.

Used in the automobile industry. Still in the present age some of the major grippers are pneumatic. The evolution of the gripper till now restricted to the two fingers / three fingers, but now it's has been taken forward by developing a robotic soft finger which has a strength and gripping friction like human body are still in development stage itself.

The main consideration of this soft finger is to grasp the irregular shape and size objects without any kind of damage to the body, this robotic soft finger is designed so that the finger sustains some the complications in its structure at the expense of small position error. To satisfy the above consideration using the 3 DOF soft finger is designed in this project work. A finger type model is made and with the reference of that a similar three more fingers are designed to that total there will be four fingers to stand which resembles the shape of human hand, there will be holes in the middle of the fingers where the wire are used to control the motion of each finger. The mechanism is structurally flexible and safe upon collision to the human body. The soft finger softness will be degraded the positional accuracy of the entire system. However the main reason of the proposed soft finger is to see its strength and the other factors for a new development aged robotic soft finger.

2. DESIGN CHALLENGE

A gripper is a part of the robot which is going to interact with the objects irrespective of its shape and size. Always a good design leads to increase in the efficiency and decreases the inaccuracy of the robot and also gives us more flexibility to improve more different tasks. In the entire history of the research in the field robotics an 'n' number of materials are been used in their systems, mostly those systems are metal rigid materials, many soft, deformable, and elastic materials were also been used. The challenges are find when the entire robotic body is designed using soft and deformable materials like silicon rubber / synthetic materials. In this we are assumed the soft finger material as silicon rubber, as we chosen the soft synthetic material for the body of the soft finger, the challenges that were faced was there is no consideration in the conventional robotics research the body can no longer be viewed as the chains of rigid links with rotational or sliding joints as typically explained in classical mechanics but they are all continuous and deformable. As we also faced the design perspective challenges as like said in the above passage including with those challenges structural analysis is also find as challenging irrespective to the design challenge, where the material used for the soft finger is silicon rubber/synthesized material for this soft finger the structural analysis can be done, but the analysis test like impact, load bearing cannot be done due to soft finger cannot with stand the huge weights as it was used to lift the weight less items and soft objects.

3. MECHANICAL DESIGN

The mechanism proposed in this soft finger was a 3 DOF mechanism which consists of a wire which acts like the nerves in the human hand, these wires are penetrated in the cross sectional areas of the soft finger hollow structure which consists of small holes. These wires are of different length, the finger can be controlled by pulling the corresponding wire. In the following below our design is explained as shown in figure (1)

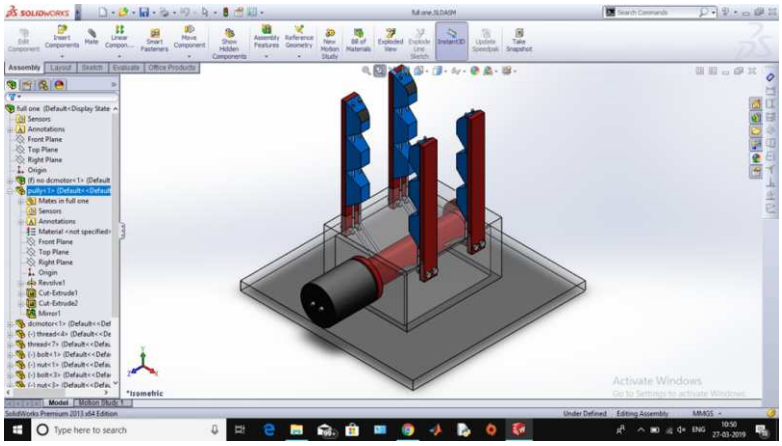

Figure 1: Soft Finger End Effector

The Soft finger is designed according to the reference of the human finger for the stability as well as for the gripping friction of an irregular shaped object. The material used for this soft finger is silicon rubber / silicon type materials which has the high elasticity in nature compared to the existing soft finger material nylon. By using the silicon type material in the design purpose is when an external force is applied to the fingers to grasp an object as by the nature the silicon type materials are elastic so there is no need of applying the force or energy to the soft finger to come back to its original position it will regain or come to its original position within a certain time.

Coming to the base structure a plane sheet layer was attached to the base, where there is square like box with all required holes to pass the wires from the motor to the fingers of the robotic arm. The base is considered to the steel material as should the base should be stronger it has been considered as a steel material in this research paper. There is about two holes which are parallel to each with a diameter of 2mm on which the shaft will be there to rotate with the help of the motor inside the cube like structure box.

In this perspective soft finger end effector the motor used for the power supply to the whole structure for the movement is DC motor while compared to the AC motor with the DC motor based on the load on the robotic arm motor has to be choose in between the AC or DC or servo motors according in reference of our soft finger end effector DC motor is suitable and the load is also low to this soft finger so there will be no need of high power motors to run this soft finger. DC Bush less motor had more efficiency compared to the normal DC motor. The servo motors are also be considered for the power supply but the it was used for the load based and accuracy cum efficiency it is used for the heavy industry level robotic arms, here we had a soft finger end effector which has to be attached to robotic arm to run this soft finger we are enough power supply from the DC motor itself. Where the Step motor is used without the presence of the position sensor, so it is was used in the every small robotic arms.

A long rod is used as shaft in this soft finger end effector which will rotated with the help of the motor we are going to use in this robotic arm soft finger it was made of steel or aluminum material so that it will be a non-conductive material to the electricity so that there will be no electric discharge or short circuit in the soft finger end effector.

4. MATERIAL PROPERTIES

The material used in this project work for designing the soft finger was silicon materials for its elasticity in nature and softness nature forwarded us to choose this material for the soft finger.

For the Silicon type material the properties are in the following range.

Table 1: Silicon Material Properties

Properties	Min.Value	Max.Value
Young's Modulus	140 GPA	160 GPA
Possions Ratio	0.265	0.275
Tensile Strength	165 Mpa	180 Mpa
Elastic Limit	165 Mpa	180 Mpa
Fracture toughness	0.7 Mpa.$m^{1/2}$	0.9 Mpa.$m^{1/2}$
Hardness	9000 MPa	10200 MPa

These are the properties of the silicon material that we have been selected in this project work for designing this soft finger end effector as shown in table (1)

And after doing the analysis the material properties that are obtained for the soft finger end effector was as follows below in table (2)

Table 2: Analysis Results for the Soft Finger

Properties	Value Obtained
Young's Modulus	427180MPa
Possions Ratio	0.23
Ultimate tensile strength	610MPa
Specific Heat	711.8J/(kg/C)
Density	3.18E-06 kg/mm^3

5. ANALYSIS RESULTS

For the whole set-up of the robotic soft finger end effector analysis has been done in the ANSYS software to get the results. Total Deformation, Von-Mises Stress, and meshing had been done on this soft finger end effector and results has been noted.

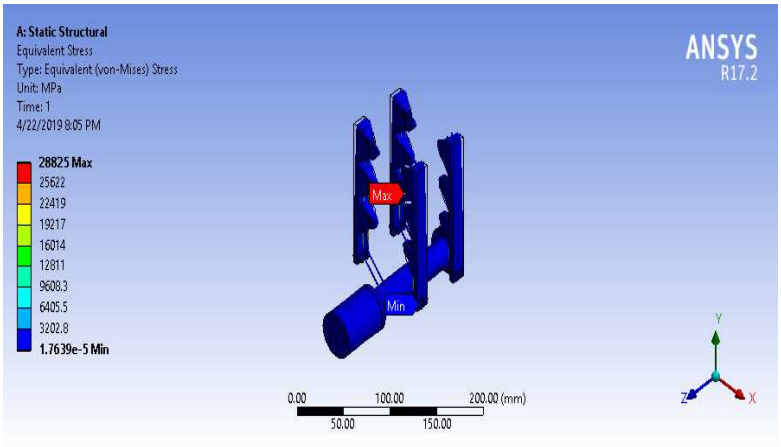

Figure 2: Von-Mises Stress Analysis

From the Von-mises stress analysis results for the robotic soft finger end effector the maximum value obtained is 28825MPa and the minimum value of this stress analysis was 1.7639e-5 as shown in the figure (2)

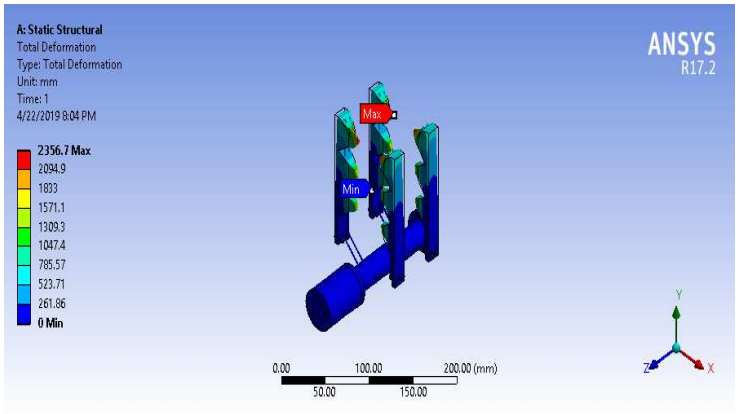

Figure 3: Total Deformation

For the Total Deformation analysis which had been done in ANSY the maximum value obtained after the analysis was 2356.7mm and the minimum value obtained was 0mm as shown in the figure (3). And coming to the meshing part the structural meshing that was done to the soft finger end effector as shown in the figure (4) & figure (5)

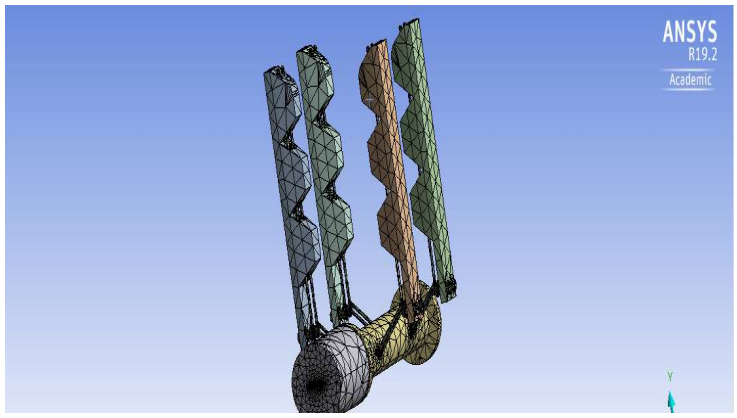

Figure 4: Static Structural Meshing

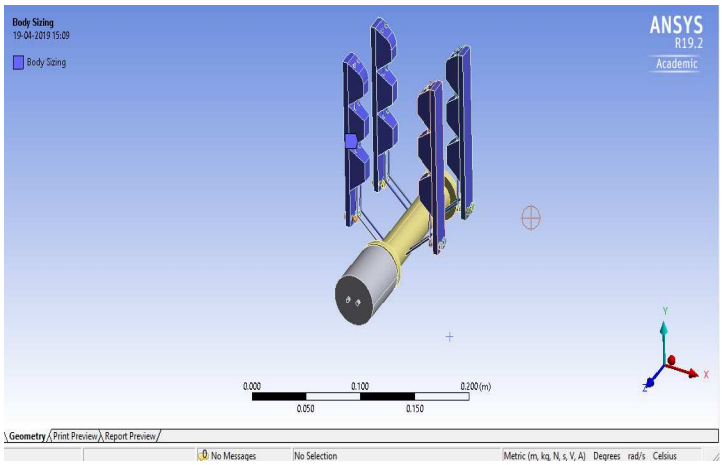

Figure 5: Meshing Analysis

On the other hand for this soft finger end effector the analysis has been done the force as well as for the moment and those two were shown as below in figure (6) & figure (7)

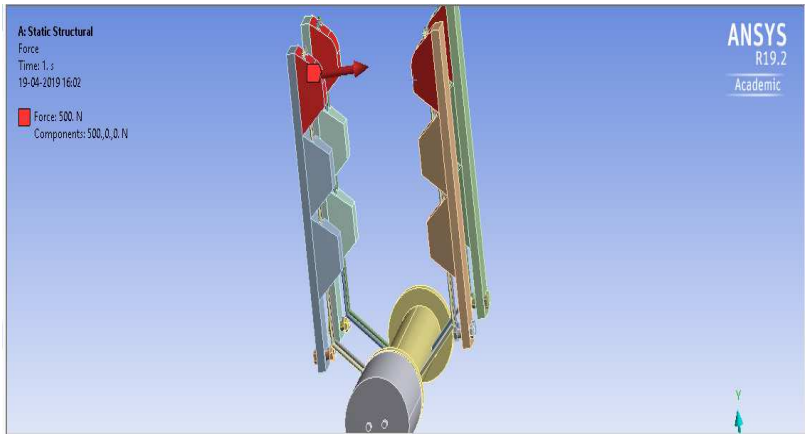

Figure 6: Force

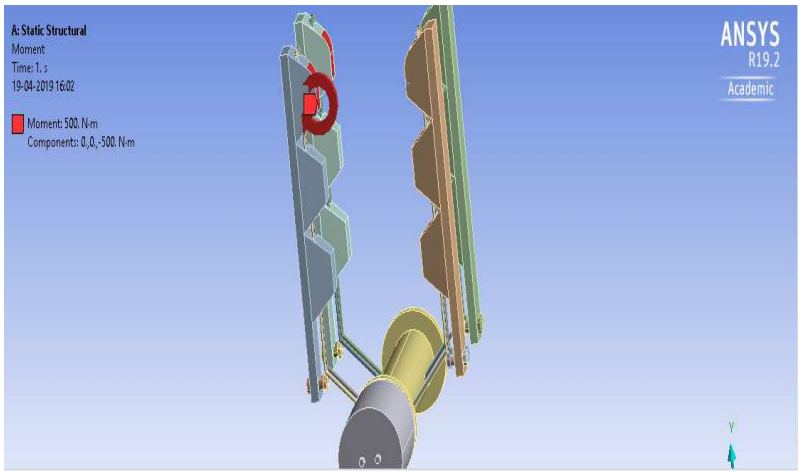

Figure 7: Moment

6. CONCLUSIONS

This designed soft finger end effector was very useful for the industrial process for handling the soft objects as well as for the irregular objects also. Obtaining the silicon material of the designing of the soft finger, will also help to the future researches on this project to use the materials which are having the elasticity as well as the strength to carry the weights/ to grasp the heavy weight objects located in industries. Using the wires in the design which helps to the fingers to come back to their original state within a certain time without any force or power required. Analysis if this whole set up is done in ANSYS as well as in ANSYS workbench. This four fingered set is an experimental and newly designed in the field of soft finger end effector, and maybe in future the implementations may be made regarding on this project, some are still in implementation stage itself, for example, of octopus model soft finger having eight fingers and having the DOF of three and also the five fingers which alike the human hand these are still under the investigation and implementation stage.

REFERENCES

1. *"Proposal of a Shape Adaptive Gripper for Robotic Assembly Tasks" Kensuke Harada∗ Kazuyuki Nagata, Juan Rojas, Ixchel G. Ramirez-Alpizar Weiwei Wan, Hiromu Onda, and Tokuo Tsuji Vol 1.0 October 2015.*
2. *"Design Evolution and pilot study for a flexible and soft robotic hand" Yun Hol Chan, Zion Tse and Hongliang ren.*
3. *"Performance analysis of a soft tip robotic finger controlled by a parallel force under kinematic uncertainties" Z.Doulgeri and Y.Karayiannidis.*
4. *"Simulation of Multifinger Robotic gripper for dynamic analysis of dexterous grasping" S.S.OHOL, S.R.KAJALE October 22-24, 2008.*
5. *"Strain Limiting for soft finger Contact Simulation" Alvaro G.Perez, Gabriel Cirio, Fernando Hemandez, Carlos Garre, Miguel A. Otaduy, 2013 IEEE*
6. *"Mechanochemically Active Soft Robots" Gergory R.Gossweiler, Cameron L.Brown, Gihan B.Hewage, William J.Trautman, Stephen L.Vraig*
7. *Oleiwi, J. K., & Hadi, A. N. (2018). Experimental and numerical investigation of lower limb prosthetic foot made from composite polymer blends. International Journal of Mechanical and Production Engineering Research and Development, 8(02), 1319-1330.*
8. *"Bending angle prediction and control of soft pneumatic actuators with embedded flex sensors – A data-driven approach" Khaled Elgeneidy*, Niels Lohse, Michael Jackson*
9. *"Soft Robotics: Challenges and Perspectives" Fumiya Iida, Cecilia Laschi*
10. *"Finger design automation for industrial robot grippers: A review" M. Honarpardaz, M. Tarkian, J. Ölvander, X. Fenga*
11. *"Design and development of a soft gripper with topology optimization" Hongying Zhang, Feifei Chen, Yiqiang Wang*
12. *Khan, S. A., & Mohammed, A. (2018). Passive control of base drag in compressible subsonic flow using multiple cavity. IJMPERD, 8, 39-44.*
13. *"Design of A Smart Gripper for Industrial Applications" Kari Koskinen 8th June 2016*
14. *"Kinematic Analysis for robot arm" Coskun Yetim, Istanbul, 2009*
15. *"Design of a Robot Gripper for a Rapid Service Robot" Tae-Jin Jung, Jun- Ho Oh April, 2013*
16. *"Design, analysis and fabrication of robotic arm for sorting of multi-materials" Zol Bahir Razali, Sep-2015*
17. *"Soft Hands: An analysis of some gripping mechanisms in soft robot design" Xuance Zhou, Carmel Majidi, Oliver M. O'Reilly*
18. *"Learning a Curvature Dynamic Model of an octopus-inspired soft robot arm using flexure sensors" Naveen Kuppuswamy, Juan-Pablo Carbajal*
19. *"Soft Robotics: Biological inspiration, state of the art, and future research" LD.Walker, W.M.Kier D.Trivedi, C.D.Rahn 2008 99-117*
20. *"Design and kinematic modelling of constant curvature continuum robots: A review" R.J.Webster, B.A.Jones*
21. *"Elastic material producing complaint robots" Rob.Auton 2007*